Investigating the relation between the Kohlrausch exponent and the fragility in polymeric systems

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Many physical quantities exhibit a universal feature in their structural relaxation behaviors. To describe such a behavior, the Kohlrausch-Williams-Watts (KWW) function, \( \phi(t) = \phi_0 \exp[-(t/\tau)^\beta] \) has been used widely. This function is characterized by the exponent \( \beta \) which takes a value in the range \( 0 < \beta < 1 \). It is believed that \( \beta \) reflects the many body interactions and it is usually considered as an empirical parameter. Therefore, in order to understand the microscopic origin of this parameter, it is valuable to study the relation of \( \beta \) with other physical quantities. Some years ago, the Bond Strength-Coordination Number Fluctuation (BSCNF) model of the viscosity has been proposed by one of the authors [1]. According to this model, the viscosity is described in terms of the average bond strength, the coordination number, and their fluctuations of the structural units that form the melt. The BSCNF model has led to an analytical expression of fragility index \( m \), which characterizes the temperature dependence of the relaxation behavior of supercooled liquids. In a previous study, it was shown that the exponent \( \beta \) can be written in terms of the quantities that describe the BSCNF model [2]. The application of the expression to metallic glass forming systems revealed that \( \beta \) decreases with \( m \). According to the BSCNF model, it indicates that \( \beta \) decreases with the increase of the degree of fluctuation of the bond strength and coordination number. In the present study, the analysis has been extended to polymeric systems. The result indicates that while \( \beta \) decreases with \( m \), its variation is gentle compared to metallic systems. The difference is interesting, because it seems to reflect the difference of connectivity between the structural units of these two systems. Details of the behavior and its interpretation will be discussed.